Automated Surveillance of Capping Operations During the 1997 Category II Project at the New York Mud Dump Site

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ACKNOWLEDGMENTS

This report presents results of the New York Disposal Surveillance System (NYDISS) program as modified with the Argos satellite telemetry option for the disposal phase of the 1997 Category II Capping Project at the New York Mud Dump Site (MDS). This report also presents the results of the cap material dispersal phase of the 1997 Capping Project at the MDS. The NYDISS program was conducted by Science Applications International Corporation (SAIC) of Newport, RI, under Delivery Order 4 of SAIC's Indefinite Delivery Contract No. DACW51-97-D-0014 with the U.S. Army Corps of Engineers - New York District (CENAN). Mr. Brian May was the manager of technical activities under the CENAN contract, and Dr. Scott McDowell was SAIC's program manager.

Logistical and planning support were provided by Mr. Brian May and Mr. Timothy LaFontaine, Master Tug Forman of all vessels at the CENAN Caven Point facility. Vessel support was provided by the able crews of the *M/V Hocking, M/V Sentry*, and *M/V Hudson.*

The success of the project was highly dependent on the cooperation extended by the Port Authority of New York and New Jersey and by the NATCO crews aboard the hopper dredges *Dodge Island, Padre Island*, and *Long Island.* The level of cooperation demonstrated by Mr. Peter Dunlop at the Port Authority and by the personnel at the dredging company was exceptional and valued.

Mr. Steve Pace, SAIC's Project Engineer, was responsible for installing and maintaining the NYDISS equipment on all vessels, and was assisted by Mssrs. Marc Wakeman and Chris McFarlane. Both gentlemen were also responsible for processing and archiving the NYDISS data files and Argos information. Ms. Diane Carle and Mr. Dave Inglin wrote the processing routines for NYDISS and Argos datasets, respectively. Steve Pace authored the report. Dr. Scott McDowell provided technical review, while Ms. Kate Spearman prepared the report.

1.0 INTRODUCTION

1.2 Background

From the end of May to the middle of August 1997, the U.S. Army Corps of Engineers (USACE) New York District (NYD) regulated the ocean disposal of partially contaminated Category II dredged material from three projects within New York Harbor and the Port of New York and New Jersey, at the New York Mud Dump Site (MDS) located 6 miles offshore Sandy Hook, N.J. Subsequent to the disposal phase of the three projects, a capping phase was performed to completely cover the partially contaminated material with one meter of sand dredged from nearby Ambrose Channel. The first phase of capping operations commenced during the third week of August and concluded 8 weeks later. A final capping phase was completed in January of 1998. Over the duration of the project, approximately 950 individual disposal/capping events took place at the MDS.

The effective implementation and management of the disposal/capping project required logging of accurate scow and hopper dredge positions during each disposal or capping event. The data from each event was incorporated into the PC-based Disposal Analysis Network for the New York District (DAN-NY) developed for the NYD by SAIC. For the efficacy of the project, NYD decided that Differential Global Positioning System (DGPS) navigation data, using differential corrections from the USCG beacon at Sandy Hook, NJ, was required for monitoring the positions of both scows and hopper dredges. Satellite telemetry of loading and disposal positions was also to have been initiated for equipped scows, since near real-time monitoring was required for day-to-day operational decisions by the NYD.

1.2 NYDISS Development

Though the development of a generic Silent Inspector System for use in USACE Districts nationwide was planned by engineers at the Waterways Experiment Station (WES), its implementation was not timely for the NYD's 1997 Capping Project. For this reason, the NYD and WES authorized SAIC under a separate contract to develop a prototype silent inspector system tailored to NYD project needs. The system was named the New York DIsposal Surveillance System (NYDISS). Two prototypes were provided to NYD in April and were tested aboard USACE vessels and scows during May 1997 (SAIC, 1998a).

The NYD anticipated that a total of eight scows would be used to conduct the disposal phase of the 1997 Capping Project. To meet the needs of the monitoring project, six additional NYDISS units were fabricated by SAIC and provided for monitoring the disposal of partially contaminated material under Delivery Order 20 of Indefinite Delivery Contract 38 with the NYD. The objectives of Delivery Order 20 were to install eight NYDISS units aboard scows and tugs through the end of August. Toward the end of the period of performance for Delivery Order 20, capabilities for near real-time monitoring were requested by the NYD; accordingly, the existing six SAIC-owned NYDISS units were retrofitted with Argos satellite telemetry Platform Terminal Transmitters (PTTs) under Delivery Order 4. NYDISS units were also installed aboard hopper dredges assigned to cap the contaminated material at the MDS during the period of performance for Delivery Order 4.

2.0 OBJECTIVE

The objective of the current monitoring project was to continue the NYDISS data acquisition program initiated under Delivery Order 20. The basic program was extended through January 1998 such that NYDISS units obtained accurate navigation data during the capping operations of the 1997 Capping Project at the MDS. In addition, SAIC retrofitted six of the existing NYDISS units with Argos PTTs to allow near real-time monitoring of disposal operations during the final days of the disposal phase of the project. The Argos telemetry option was not installed on the hopper dredges dispersing cap material at the MDS.

To summarize the objectives, SAIC provided:

- Six NYDISS units retrofitted with Argos satellite data telemetry transmitters.
- Field service and data acquisition for multiple NYDISS units aboard dump scows and hopper dredges at 5-day intervals during the latter portion of the disposal phase and at 7-day intervals during the capping phase.
- Re-installation of NYDISS units when scows were rotated into service.
- Processing and quality control of the NYDISS data files recovered during servicing.
- Access to NYDISS data maintained within the DAN-NY system.
- Accurate dredged material disposal and cap dispersion location information.

The results from this Delivery Order were used by disposal site managers from the NYD and engineers from WES to accurately assess the placement of dredged material and cap material during the 1997 Capping Project at the MDS. The disposal position data were valuable input to WES' MDFATE model which was used by the NYD to hindcast the 1997 Capping Project. The data were also used to interpret interim sediment coring data acquired for the geotechnical analysis of the disposed material and subsequent cap placement (SAIC, 1998b).

3.0 SYSTEM DESCRIPTION

A thorough description of the NYDISS system including the requirements, design, components, logic, data flow, and data file format is contained within the report to WES describing the prototypes produced and tested (SAIC, 1998a). Figure 3-1 illustrates the major NYDISS components. The following description details both the Argos retrofit for near real-time scow monitoring and the hopper dredge (capping) mode of deployment.

3.1 System Requirements

Argos system requirements under Delivery Order 4 included:

- Near real-time monitoring of scow loading and disposal events.
- Rapid data processing and display to facilitate daily operational decisions at the NYD.
- Easy installation on scows within 60 minutes.
- Simple system diagnostics to determine equipment operational status.

The NYDISS requirements for capping operations aboard hopper dredges included:

- Unattended operation on hopper dredges with weekly service visits.
- Easy installation on hopper dredges with 30 minutes for installation.
- Simple system diagnostics to determine equipment operational status.
- Easily understood operation instructions for on-board disposal inspectors.

3.2 System Design and Components

The original design of NYDISS was retrofitted with Argos PTT equipment. The Seimac Smart Cat MUX PTT was selected for its compatibility with existing NYDISS components. The Smart Cat is a low-power unit capable of receiving data stored in the LCU buffer for transmission once every two hours to polar orbiting Argos satellites. The PTT equipment consisted of a digital signal board and a radio frequency transmitter board: The digital board processed the data strings received from the LCU buffer, and the radio frequency board transmitted a low-power (1 watt) signal to passing satellites.

The other modification to the NYDISS equipment provided a means to manually record disposal events during capping operations without the installation of a pressure sensor to determine changes in vessel draft. Instead, a switch closure was added to the units installed on hopper dredges to allow the human inspectors to flag positions where capping occurred. Activation of the switch caused a flag or marker to appear in the data string and a blue Light Emitting Diode (LED) to illuminate through the face plate of the NYDISS box. The inspector activated the switch when disposal began and deactivated it at the end of the operation, setting the flag in the data strings for those positions occupied during disposal. The attributed data were then processed and displayed using the software routines established for rapid turnaround and transmission to the NYD. A description of the software routines was presented in the previous Delivery Order 20 Final Report (SAIC, 1997).

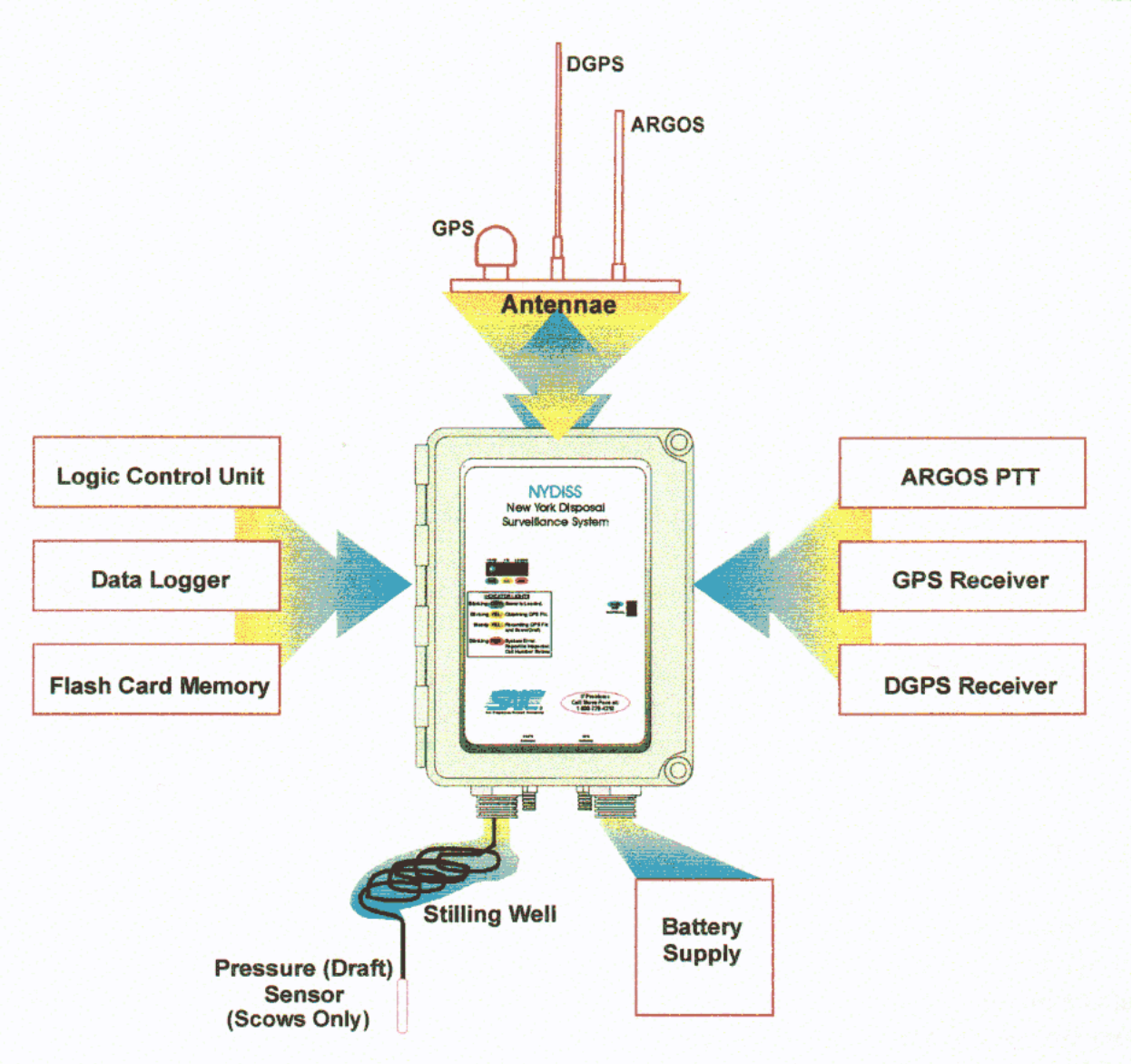

Figure 3-1. Major components of NYDISS system.

3.3 System Logic

The programming contained within the PROM (Motorola 6805 series) located on the LCU was also modified to accommodate the requirements of the Argos PTTs. Timing sequences between other NYDISS components and the PTTs were established to facilitate the addition of the second data stream from the LCU buffer to the digital signal board without interfering with the recording of data strings by the Flash RAM Memory Card. In this instance the NYDISS program sent subsets of the data to the PTTs for transmission, while maintaining its complete internal data recording capabilities. A complete set of NYDISS data could not be transmitted through the Argos system, because the system capacity was limited to approximately 1 kilobyte per day or two 32-character records every two hours. The limitation required the selection of a subset of data normally stored within the Flash RAM Memory Card of NYDISS for transmission through the Argos system.

The PROM program selected the data to be transmitted based on the options chosen during the installation of the equipment on the disposal scows. The user could choose to send the first data string locating the disposal event and one other data string. The choice of the record data string was made to bracket the position where the load was dropped at the disposal site between the first string and the last. If, for instance, a scow was loaded with unconsolidated material, which left the bin quickly during disposal, the first and second fix were selected. However, if a scow was prone to drop its contents more gradually over a thirty-second period, then the first and fifth fixes would be selected during setup procedures (fix intervals were six seconds).

The system logic for the unit installed aboard the hopper dredges remained as originally programmed for the prototype units. No data were transmitted through Argos because of its limited transmitting capability. Parameters that remained constant throughout the capping program were the sampling intervals. The latitude value below which sampling first began for the hopper dredge, *Dodge Island*, was 40.430° N, corresponding to the entrance of Ambrose Channel. Initially, set at 40.500° N for the *Padre Island*, the first latitude was set at 40.450° N. In both vessels, the second latitude below which the sampling rate intensified was 40.380° N, the northern boundary for the 1997 Capping Project grid. The initial rate of sampling was set at thirty seconds below the initial and above the second latitudes. The intense rate of sampling within the project grid was set to once every six seconds.

3.4 Data Flow

Data flow within the NYDISS units began with strings of ASCII differentially-corrected GPS (DGPS) information sent to the LCU, where they were appended with pressure, battery voltage, cap flag and status code information. (A description of the data strings was included in the description of the NYDISS prototype developed for WES, e.g., SAIC, 1998a). Within the LCU buffer a subset of the data was sent to the Argos unit for coding and transmission, while the complete set of NYDISS data was stored in the non-volatile flash memory (Figure 3-2). Once transmitted, the Argos subset was received by a passing satellite and transmitted to a ground station for decoding and delivery via e-mail. Received at the SAIC Newport facility, the Argos data were checked for errors, then parsed and entered into the database before they were plotted in a GIS display.

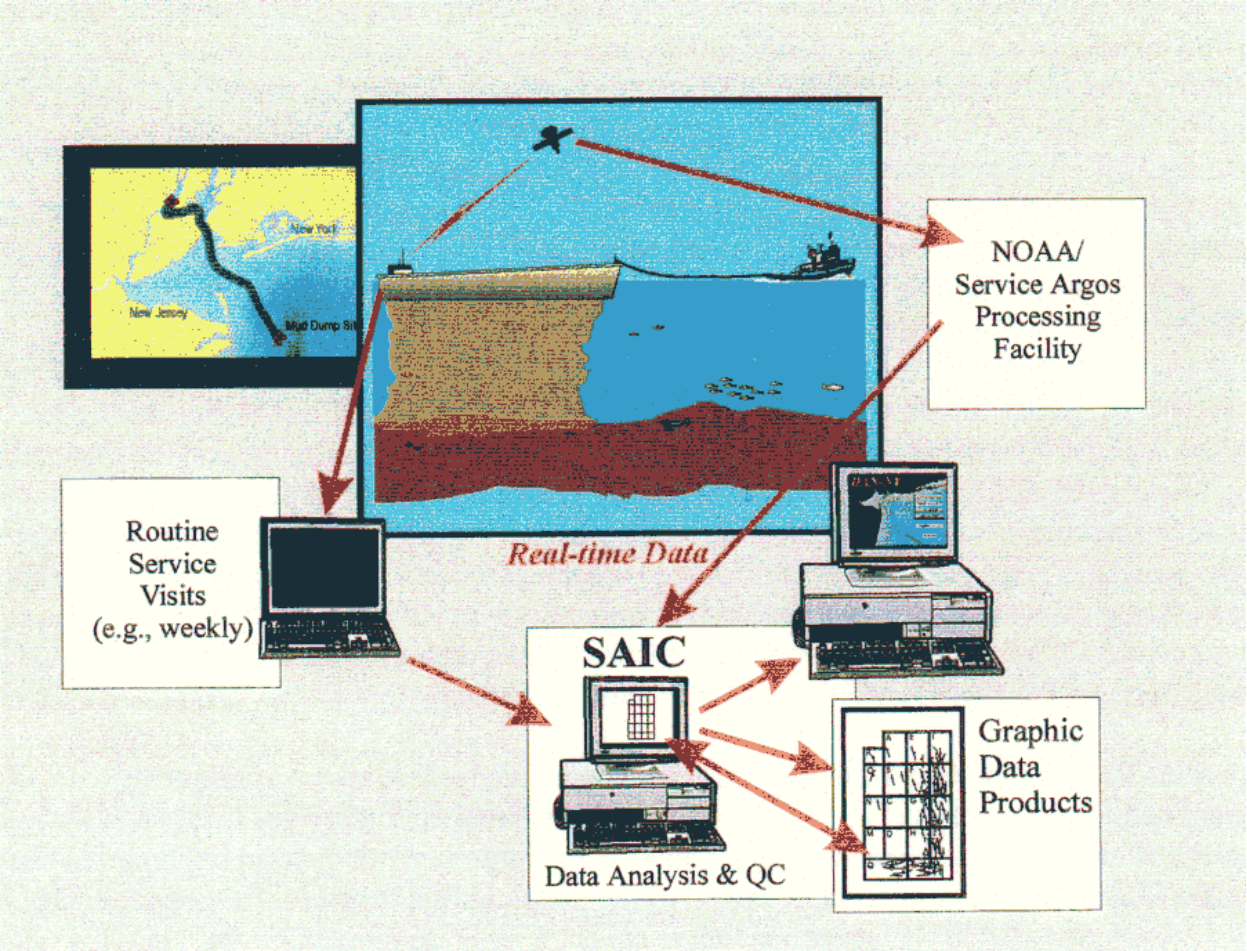

Figure 3-2. NYDISS data flow through the Argos pathlink during the 1997Capping Project at the New York Mud Dump Site.

Data stored within the NYDISS units installed on either the disposal scows or the hopper dredges were retrieved at the work site during service visits and downloaded from the PMCMIA memory card into a laptop computer. The data files were then compressed and transmitted from the work site to the SAIC Newport facility for processing through a dial-up e-mail account. Processing of the stored data then followed the procedures established for Argos-transmitted data once they were error checked for accuracy and parsed.

4.0 NYDISS MONITORING

Both disposal and capping types of NYDISS installations were distributed between three scows and three hopper dredges, spanning the period July 29, 1997 through January 18, 1998. The loading position of the scows was the Confined Disposal Facility (CDF) located in Newark Bay, and the loading location of the hopper dredges was the outer reach of Ambrose Channel.

4.1 Argos Modifications to Disposal Scow Monitoring

Modifications to NYDISS hardware and firmware to facilitate near real-time transmission of data began June 23. As part of the present scope of work, six SAIC-owned NYDISS units were retrofitted with Argos PTTs and placed on scows within the last twelve days of the disposal activities in July and August 1997. The existing NYDISS hardware was retrofitted with the PTT equipment supplied by Seimac Ltd. within a five-week period after receiving contract authorization to proceed from NYD. Power and signal input for the PTT were supplied from shared DGPS receiver pinouts on the LCU board. The PTT components were added to the chassis containing the NYDISS components within the weather-proof housing.

4.2 Scow Monitoring

Within the last twelve days of the disposal activities in July and August 1997, three SAIC-owned NYDISS units, retrofitted with Argos PTTs, were placed on scows. Both the hardware and firmware modifications were tested during the twelve-day trial period. During the first five days of the trial period a timing conflict between the logger component and the PTT was discovered, which prevented the internal logging of data by the previously proven firmware. The conflict was resolved by reprogramming the LCU to provide a longer internal wait time, and subsequent data acquisition occurred without further loss of information.

4.3 Hopper Dredge Cap Monitoring

Initial capping operations began August 20 on one of the two 4,000 cubic yard hopper dredges and continued through October 21, 1997 with both the *Dodge Island* and the *Padre Island*. Capping resumed for nine days on November 18, and again for selected cells within the grid with the *Long Island* during January 6 - 18, 1998. NYDISS monitoring took place during all periods of capping operations, but without the Argos data telemetry capability.

***Dodge Island* and *Padre Island* Operations.** NYDISS monitoring equipment was installed on the *Dodge Island* August 20, and on the *Padre Island* during August 27, 1997. Thereafter, each was serviced on a 5 to 7-day schedule until the *Dodge Island* was removed from service on October 2. Service continued on the *Padre Island* until October 21 when it transited to repair facilities for service and the progress of the cap material placement was assessed by the Port Authority and the NYD.

The installations aboard the two self-propelled 4,000 cubic yard hopper dredges were simple and effective. NYDISS units were placed in the wheel houses of both vessels, and the inspectors

were trained in the operation of the equipment. Each installation took approximately one hour to complete.

The Argos telemetry retrofit of the NYDISS monitoring equipment was not used during the hopper dredge operation, because it was not practical to bracket dispersal events. Disposal events typically took 20 to 30 minutes to complete, and the load-transit-disposal cycle for the two dredges was short, sometimes allowing as many as eight cycles per day.

***Long Island* Operations.** The NYDISS installation aboard the integrated capping vessel (the 12,000 cubic yard hopper dredge *Long Island* and the tug *William Colnon*) was difficult to maintain because of several problems encountered with the operation of the 600-foot dredge. The original installation which occurred during the November capping effort failed to produce disposal data, due to poor GPS antenna location on the tug. The second attempt during January 1998 to acquire NYDISS data from the tug was successful. After the installation of the GPS antenna was achieved by placing it at the top of the tug's mast, the NYDISS logger was located in the upper wheel house where the inspector was stationed. After the first of seven disposal events was successfully logged, the NYDISS unit failed, and no data were acquired during the second and third disposal trips. Upon discovery of the failure, the navigation output from the NYDISS unit was logged to a palmtop computer during subsequent disposal operations. Later, when the failure of the NYDISS equipment was analyzed, it was determined that the persistent vibration of the tug caused by constantly maneuvering the composite vessel into position for disposal had loosened the connections of the logger from the LCU. Though navigation data were received by the unit, they could not be logged due to a break in the connection.

Since the cells requiring cap material were small and isolated about the grid, disposal operations on the *Long Island* required at least 2 to 3 hours to complete for each load. Each load-transit-disposal cycle lasted one day. Constant maneuvering was necessary to keep the 600-foot vessel in position. In addition to the vibration, the maneuvering of the integrated vessel resulted in a convoluted trackline record, as the composite was not driven on a straight course.

5.0 DATA PROCESSING AND ANALYSIS

For the analysis of both the Argos/NYDISS Category II material datasets and the NYDISS capping material datasets, a series of processing procedures and Quality Control checks were developed and performed. Processing routines were written in Visual Basic™ and mapping deliverables were produced in ArcView™. The datasets containing scow navigation and draft data, and hopper dredge navigation data were archived and made ready for inclusion into the DAN-NY system during the Fall of 1997.

Under Phase 4 of the ongoing DAN-NY support project, the NYDISS data sets from the disposal scow operations have been added to the database, and a new application was developed for display. The database within DAN-NY has been updated from the database created for NYDISS processing. Display options within DAN-NY allow the user to create plots of the scow transit tracklines and disposal events at the MDS. In its current version, DAN-NY will not include the Argos telemetry data gathered from the disposal scows nor will it contain the voluminous NYDISS capping information.

5.1 Data Processing Procedures

Argos Data from Disposal Events. The Argos/NYDISS datasets were processed using a Visual Basic™ routine written for the purposes of parsing and editing the navigation information, and creating a database for mapping. Raw data flowed into the routine from the Service Argos Automatic Distribution System through an e-mail address, where they were parsed, edited and used to update the database of disposal locations before being plotted in ARCView™. Data from the Argos processing were plotted over a disposal grid of the 1997 Capping Project to show the two navigation fixes transmitted for all disposal events in a given time frame for a particular scow (Figure 5-1).

NYDISS Data from Capping Events. The NYDISS capping information acquired from downloading navigation information during service visits to the installations consisted of strings of navigational fixes in ASCII format. The data were previewed and examined for empty, incomplete or mismatched files in a summary table created within the Visual Basic™ routine. Once parsed, the program graphed the navigation data in a sequence of fixes, showing the disposal locations flagged in the record by the human inspector. The database originally constructed during the preview phase was then updated with the chosen disposal start and end points in preparation for mapping.

The results of the analyses of capping data were displayed by importing the database into ARCView™ and by creating an event theme from the Latitude and Longitude information within the project capping area. The area, according to the design of the capping plan created by CENAN, WES and SAIC, was outlined within the MDS. The data representing a single trackline for each cap dispersal were plotted over the area and displayed as a series of bold dots (Figure 5-2). A weekly summary of events was created by graphing all of the points acquired over the area (Figure 5-3). The data products, like Figures 5-2 and 5-3, were produced weekly and faxed to CENAN as a tool for guiding operational decisions during the disposal program. In addition, WES was supplied with the data to compare with MDFATE model predictions.

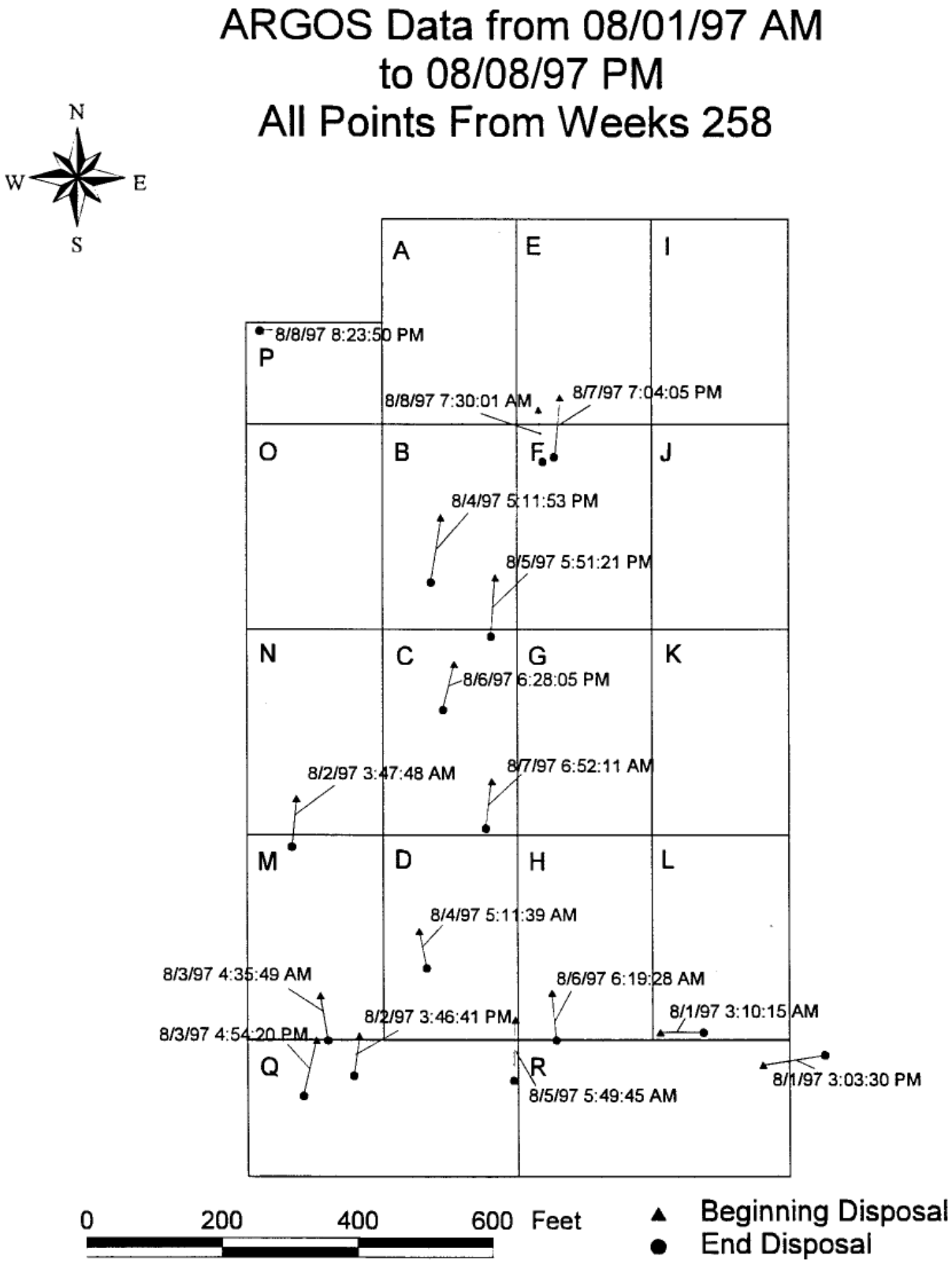

Figure 5-1. Argos telemetered DGPS scow positions plotted in near real-time at the Mud Dump Site during the disposal phase of the 1997 Capping Project.

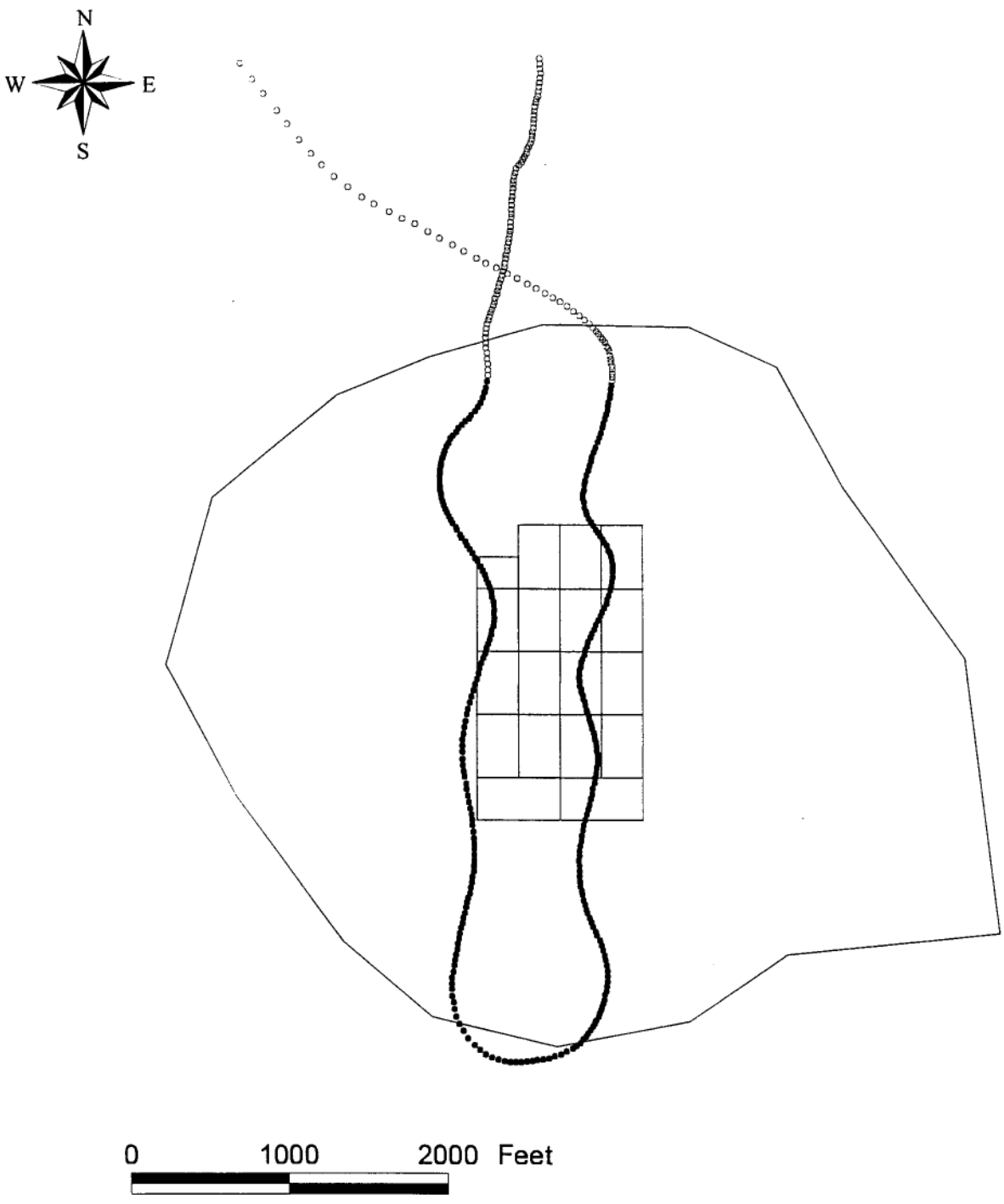

Figure 5-2. Sequential DGPS positions occupied by the hopper dredge *Dodge Island* during a capping dispersal trip within the 1997 Capping Project disposal grid.

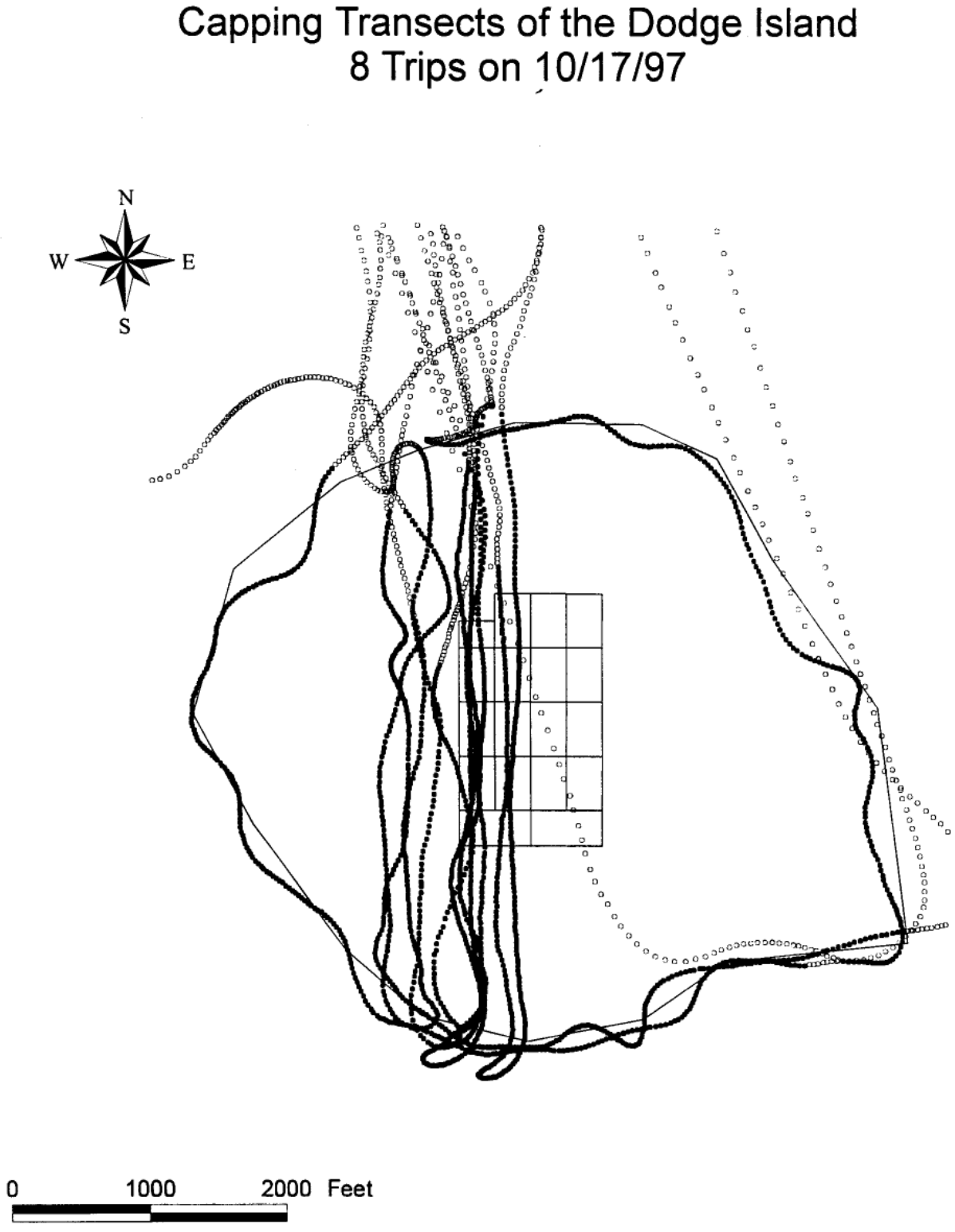

Figure 5-3. Sequential DGPS positions occupied by hopper dredge, *Dodge Island* during 8 capping trips within the 1997 Capping Project disposal grid.

5.2 Data Acquisition

Argos Acquisition. Argos data from the CDF Category II disposal project were acquired from three scows during the final 12-day period of the operation (July 28 to August 10,1997). In total, 43 disposal trips were made with Argos-equipped units installed on board (Table 5-1). Twenty-four records were successfully acquired from the Argos-equipped installations. Nineteen of the disposal trips were not recorded, because of a firmware programming error, which prevented the data from being logged internally and transmitted through Argos. In addition to the firmware problem discovered during the test period, electrical interference on Weeks 259 also prevented the NYDISS equipment from functioning.

NYDISS Acquisition from Capping Events. From a total of 650 capping trips, 600 were internally recorded by the NYDISS equipment installed aboard the three hopper dredges, *Dodge Island*, *Padre Island* and *Long Island* (Table 5-2). Almost all of the disposal trips taken by the *Dodge Island* and the *Padre Island* were successfully recorded. Of the missing information, a firmware error prevented data from being acquired. Once discovered, the error was corrected by the NYDISS service crew and tested. Both poor GPS antenna location and severe vibration caused the failure of the NYDISS equipment to record some of the navigation data aboard the *Long Island*. Fortunately, a better antenna location was found by the field crew and some of the trackline data was logged with a palmtop computer. In total, a 92-percent rate of data recovery was realized during the 3-month capping phase of the 1997 Capping project.

5.3 Data Analysis

The succession of capping phases is illustrated using the NYDISS data acquired by the three hopper dredges. The data acquired during the first two months of cap placement from the *Dodge Island* and the *Padre Island* were plotted in Figure 5-4 to show the relative density of disposal tracklines over the cap disposal grid. The density of tracklines was greatest along the center and across the northern areas of the grid, while little cap material was placed outside the grid boundary (Figure 5-4). A summary figure of navigation positions occupied during the first phase of cap placement was used, in conjunction with concurrent bathymetric surveys carried out by SAIC for the Port Authority of New York/New Jersey, to determine the locations of continued cap placement operations (Figure 5-5). This figure clearly showed the least amount of cap placement occurred at the southeast margins of the grid.

After the initial phase of cap placement was analyzed for coverage over the Category II dredged material disposal mound, a second and third phase of capping operations began with the *Long Island.* Data from the second phase was not acquired with the NYDISS equipment installed, because of poor GPS antenna location. Data from the third phase shows the areas covered with cap material during disposal (Figure 5-6).

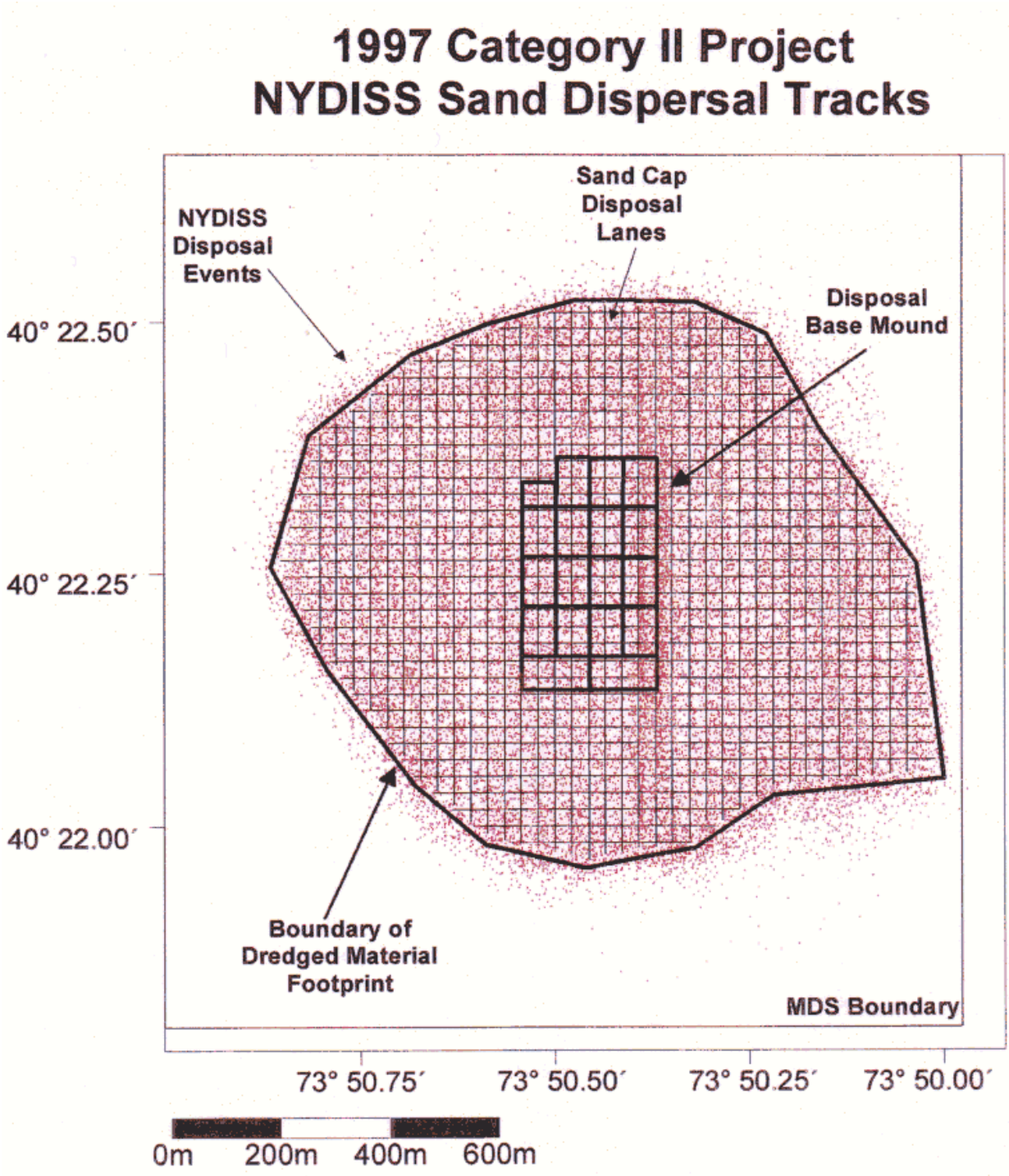

Figure 5-4. The cumulative number of DGPS fixes recorded by NYDISS systems installed aboard the hopper dredges *Dodge Island* and *Padre Island* during cap dispersal operations from August 20 to October 21, 1997, at the Mud Dump Site.

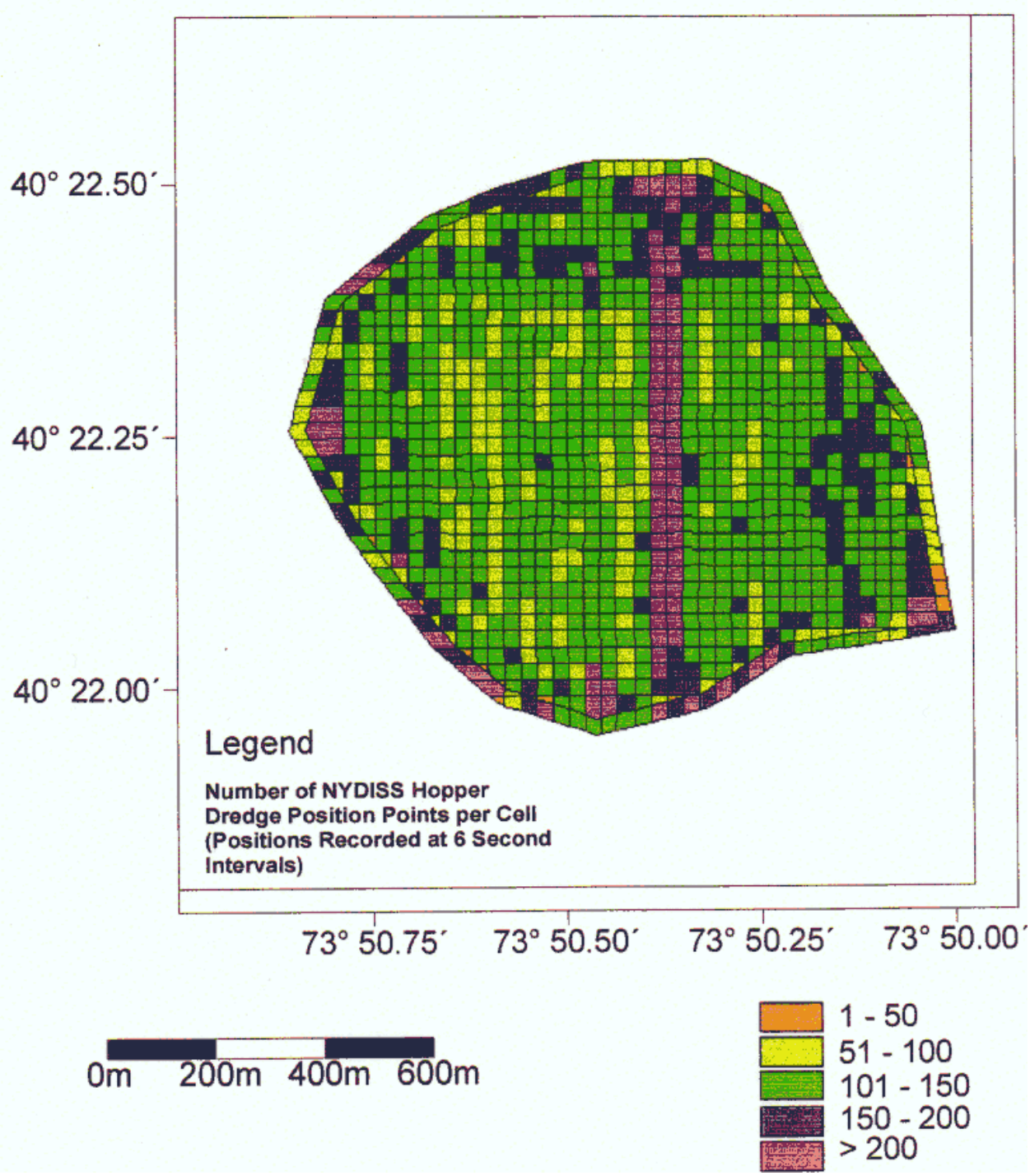

Figure 5-5. Total number of DGPS fixes recorded by NYDISS systems installed aboard the hopper dredges *Dodge Island* and *Padre Island* during cap dispersal operations from August 20 to October 21, 1997, at the Mud Dump Site.

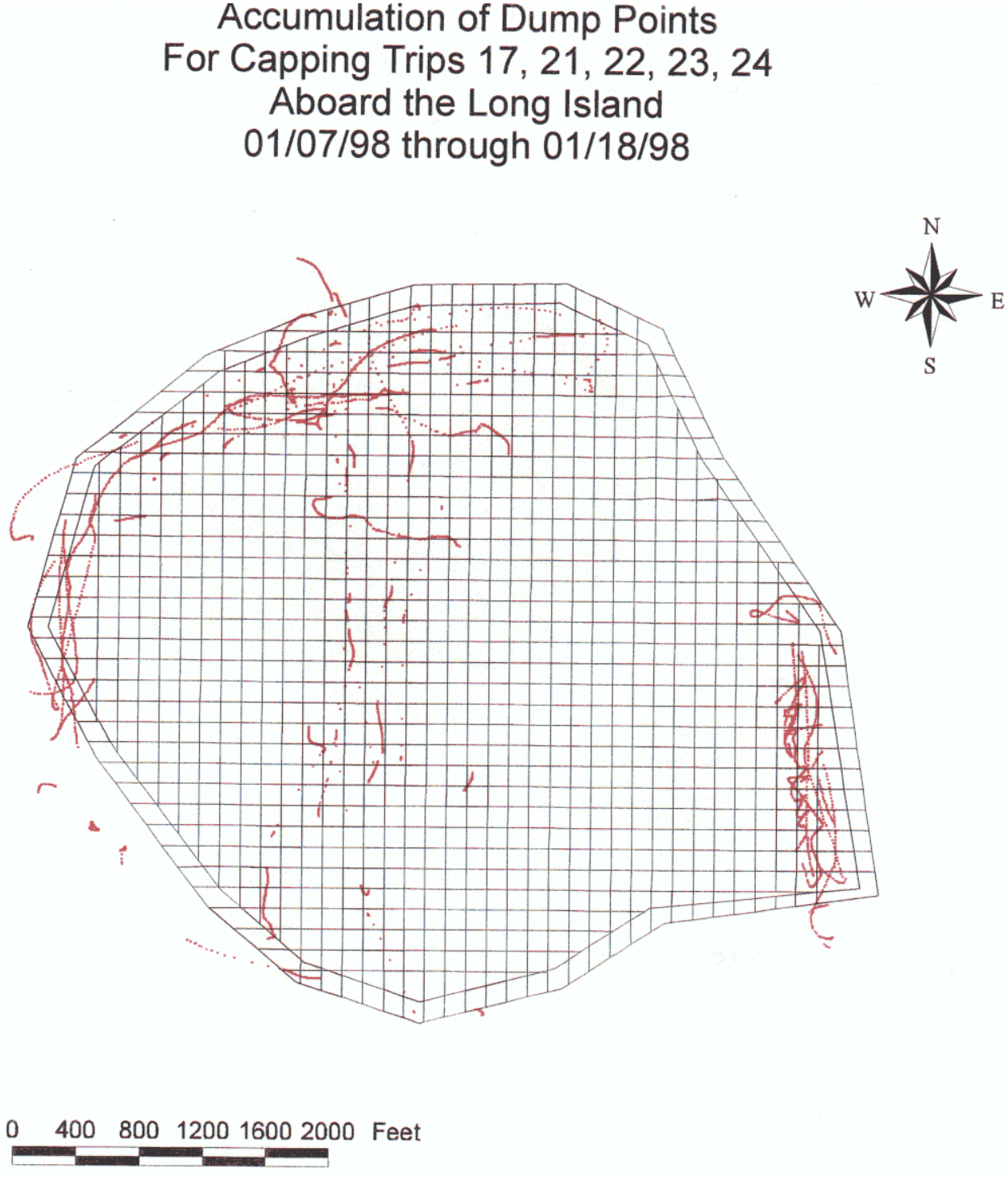

Figure 5-6. The cumulative number of DGPS fixes recorded by NYDISS systems installed aboard the hopper dredge Long Island, during cap dispersal operations from November 18 through November 26, 1997 and from January 6 through January 18, 1998 at the New York Mud Dump Site.

5.4 Argos Versus NYDISS Data Comparison

A comparison between the data sent through the Argos satellite system and the complete trackline data recovered from the NYDISS internal memory provided a basis for evaluating the efficacy of using near real-time data as a tool for day-to-day operational management. To graphically illustrate this comparison, three disposal events with matching sets of Argos and NYDISS data within the grid, are presented in Figures 5-7, 5-8, and 5-9; the first position of each Argos pair lagged behind that plotted from the internally recorded NYDISS data. The lag appeared to be related to the speed of the tow. Where the six-second fixes occur close together, indicating a slow speed (~1 kn [Figure 5-7]), the offset between the Argos positions and the disposal positions as determined by the NYDISS data was minimal. Conversely, when the scow was traveling faster (~4 kn), as shown by position fixes spread farther apart (Figure 5-9), the offset was more noticeable.

The bracketing of each disposal event depended upon both the speed of the tow and the estimated length of time for disposal. When the tow speed was greatest and the time of disposal was 12 to 18 seconds, the Argos data tended to show only a portion of the disposal (Figures 5-8 and 5-9). However, as the speed of the tow decreased and the time of disposal was shortened to six seconds, the Argos data closely approximated the NYDISS recorded data (Figure 5-7). The difference between the two data sources was significant where faster tow speeds were observed. The disposal illustrated in Figure 5-9 partially occurred outside the grid, though Argos showed a disposal within one of the cells.

When used to assess the effectiveness of disposal within the grid, the observer can take note of the distance between the two plotted Argos positions as an indication of tow speed and accuracy of the plotted event. If the location occurs near the margins of the disposal grid, the entire disposal may not have occurred where indicated. Regardless, a comparison of Argos and full NYDISS data should be made to evaluate the true position of the disposal.

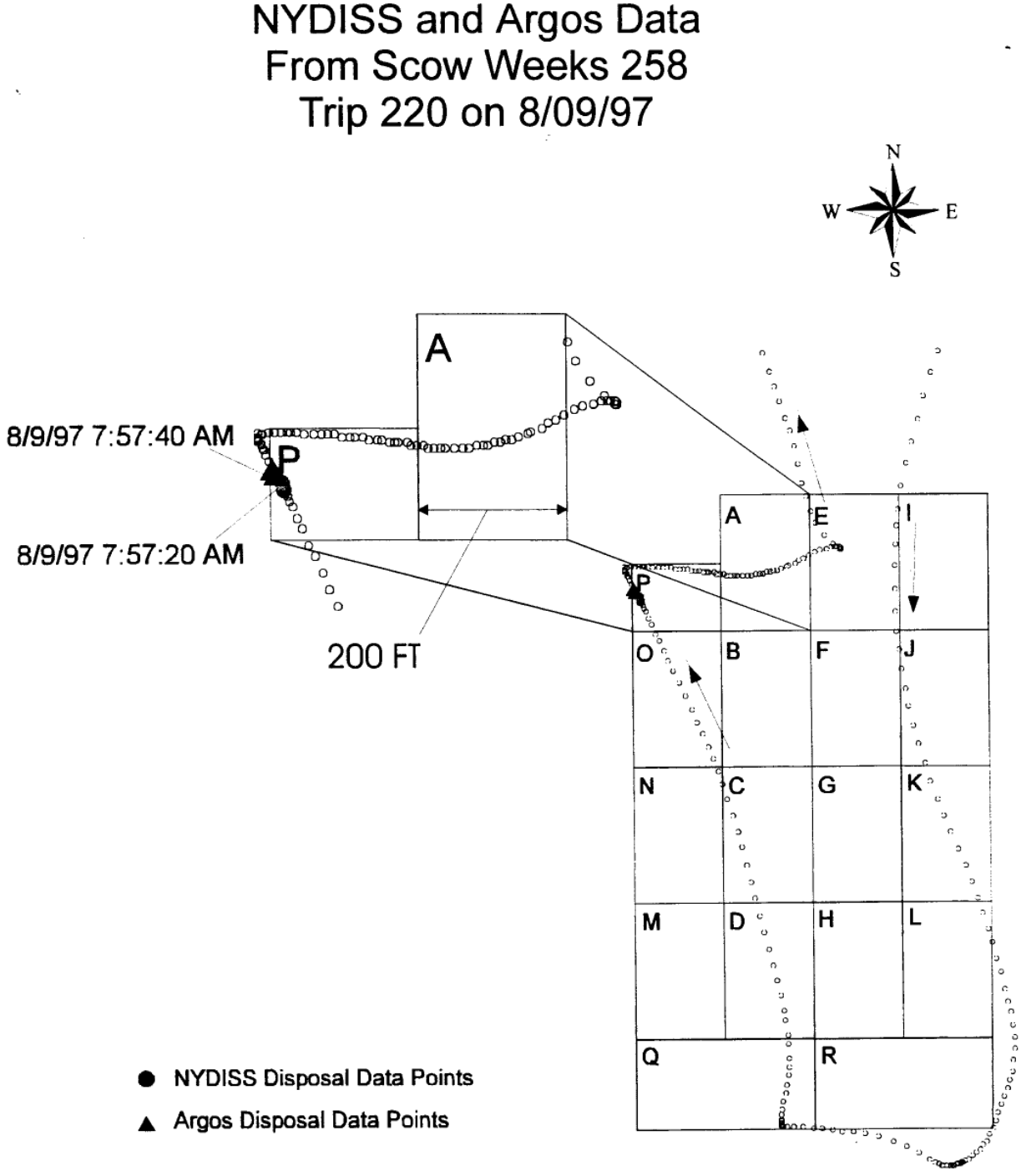

Figure 5-7. A comparison of Argos transmitted data and NYDISS internally recorded data acquired during disposal trip 220 on August 9, 1997, at the Mud Dump Site.

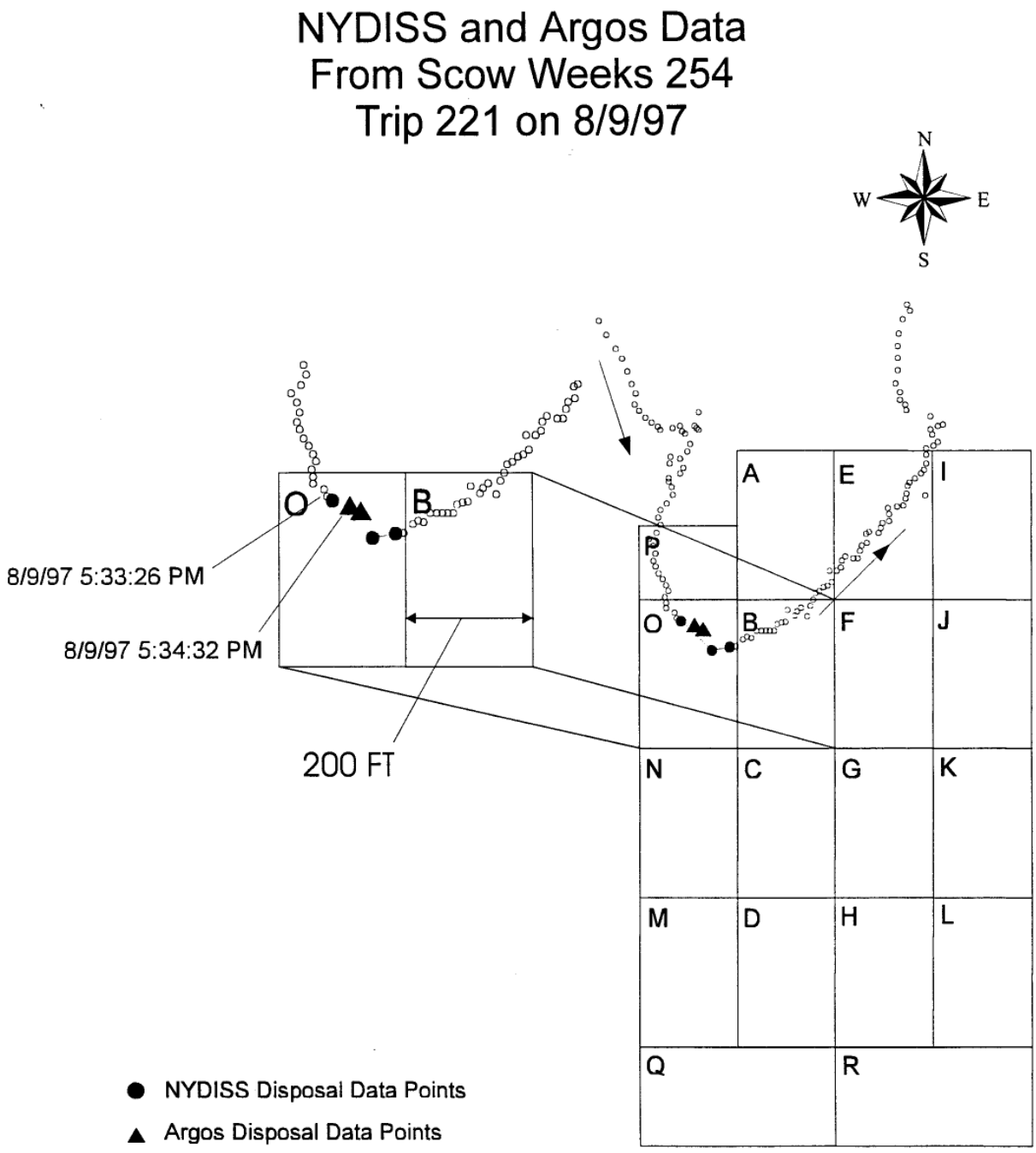

Figure 5-8. A comparison of Argos transmitted data and NYDISS internally recorded data acquired during disposal trip 221 on August 9, 1997, at the Mud Dump Site.

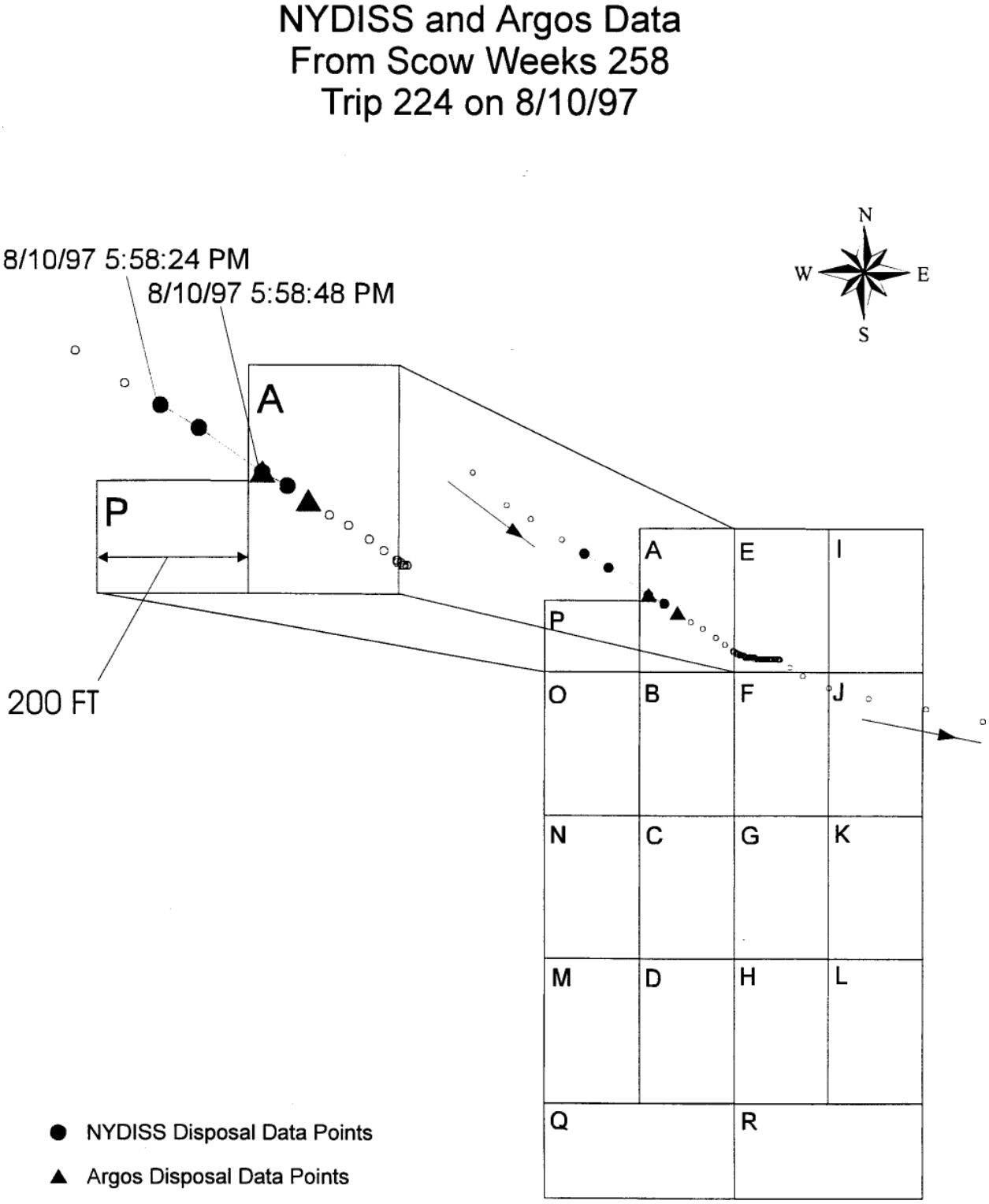

Figure 5-9. A comparison of Argos transmitted data and NYDISS internally recorded data acquired during disposal trip 224 on August 10, 1997, at the Mud Dump Site.

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